CALIFORNIA DIVISION OF MINES AND GEOLOGY
FAULT EVALUATION REPORT FER-221

Faults in the Devils Garden Plateau, Modoc County

by
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INTRODUCTION

North and northwest-trending normal faults cross the "Devils Garden plateau" (an informal term referring to the large plateau north of Alturas and west of Goose Lake). Many of these faults have formed scarps in the late Tertiary volcanic rocks that form the surface of the plateau. Many of these faults are shown as Quaternary by Jennings (1975); some have formed scarps that appear to be geomorphically "fresh" and all lie within the current Modoc Plateau study region. These faults are evaluated here for possible zoning under the Alquist-Priolo Special Studies Zones Act (Hart, 1988).

SUMMARY OF AVAILABLE DATA

Faults in the volcanic rocks of the Devils Garden Plateau were first mapped by Gay and Aune (1958). Their published map (the Alturas Sheet of the Geologic Map of California) shows a set of faults that trend about N20°W, are generally less than 20 km long and are somewhat arcuate and concave to the west in their map pattern. Their field sheets, used in the compilation of the published map, show a denser and more complex pattern of faults in this area. Apparently the interpretation of aerial photographs by Gay and Aune (unpublished) was simplified and considerably edited prior to publication. The fault traces from the original field sheets have been transferred to 15' quadrangles for this report (Figure 2b, c, d and e). The original field sheets for the Steele Swamp, Jacks Butte, South Mountain and Willow Ranch Quadrangles were prepared using advance sheets of the 15' quadrangles that did not show topography. The field sheets for the Clear Lake Reservoir and Big Sage Reservoir Quadrangles were missing from the Regional Geologic Mapping Project files.

Gay and Aune (1958) show these faults in Miocene, Pliocene, undifferentiated Tertiary and Pleistocene basalts. McKee and others (1983) have shown that the entire surface of the plateau is made up of basalt flows of very similar composition that range in age from five to ten million years. No Pleistocene basalt has been recognized in this area based on this most recent work. It

is therefore not possible to determine when faulting occurred in late Tertiary or Quaternary time based on the volcanic units offset.

The faults of the Devils Garden were also mapped by J.L. Burnett (unpublished) for the Fault Map of California (Jennings, 1975). Overlays for each of the 15' quadrangles in the area were prepared and later reduced and simplified for printing at 1:750,000 scale. The overlays were retained in the Regional Geologic Mapping project files. The faults from these overlays have been transferred to Figures 2a, b, c, e, and f. The overlay for the Hackamore quadrangle was missing from the Regional Geologic Mapping Project files.

The faults mapped by Burnett generally agree with those mapped by Gay and Aune (unpublished) although many of the traces do not exactly coincide and many additional faults were mapped by Burnett. The non-topographic base maps used by Gay and Aune probably caused their locations to be somewhat inaccurate.

INTERPRETATION OF AERIAL PHOTOGRAPHS AND FIELD CHECKING

Geomorphic evidence for recent faulting was interpreted from aerial photographs and plotted on 15-minute topographic map (Figures 2a, b, c, d, e and f). Faults in the south-central part of the area were plotted on 7.5-minute topographic maps (Figures 3a and 3b). Aerial photographs of approximately 1:24,000 scale taken by the USFS in 1984 were used for the majority of the area. Parts of the south and east margins of the Devils Garden Plateau are covered by 1:20,000 scale photographs taken by the USDA in 1955.

Geomorphic expression of faulting and units offset by faults in one small area were field checked on October 3, 1990 (Localities 2 and 3, Figure 3b). Evidence for recent faulting was noted on the most prominent and "freshest" appearing fault in the area. Field checking of the great majority of the faults, particularly in the northern and western parts of the Devils Garden Plateau was not attempted because these scarps did not appear to be as active on aerial photographs and because of the limited time available.

The faults mapped by Gay and Aune (unpublished) and Burnett (unpublished) were generally confirmed based on aerial photo interpretation. Those faults that have been confirmed are marked with a check on Figures 2a, 2b, 2c, 2d, 2e and 2f. Faults were confirmed if their trace was within about 500 feet of the trace interpreted from aerial photos. Most traces by Gay and Aune are plotted on base maps without topography; those by Burnett are on

overlays without an attached base map. It is likely that many traces were slightly mislocated or not precisely transferred to the 15' quadrangles used for this study. No attempt was made to correct these locations because of the limited time available for this study.

These faults are generally 10 to 25 km long and trend about N20°W. They form degraded scarps and linear ridges, and vegetation lineaments. West facing scarps are up to 50 m high but most are less than 10 m high. East facing scarps are generally less common and smaller. Short, northeast trending faults are also conspicuous because they give parts of the area a distinctive cross-hatched appearance. Most of the northeast-trending faults and many northwest-trending faults were mapped on the basis of vegetation lineaments only.

These features are found on a nearly flat, sparsely forested basalt plateau. The fault features tend to be well defined, at least as vegetation lineaments, but very little of the original lava flow pattern or morphology can be observed on aerial photographs. Because the faults are much more clearly defined than the original volcanic structures, the faults are probably considerably younger than the 5 to 10 million year old basalts. It seems likely that much of the faulting occurred in Quaternary time.

A set of higher, north-trending, east-facing scarps follows the west side of Goose Lake (Figures 2c and 2f). These scarps are up to 180 meters high and form a zone about 3 km wide and 50 km long. They are degraded, talus-covered and incised by minor drainages, suggesting a lack of latest Quaternary displacement, but are high and steep, suggesting that displacement has occurred in Pleistocene time. A line of ground cracks and springs of sinkholes in the bed of Goose Lake appears to be related to these faults (Figures 2c and 2f). This linear feature may be a groundwater barrier related to a buried fault. It is probably not an active fault because the nearby, parallel fault scarps are degraded and do not appear to be active.

Other relatively high north-trending scarps were mapped in the south-central part of the Devils Garden Plateau. Because these scarps appear to be relatively sharp, and have varying degrees of preservation, parts of five 7.5-minute quadrangles were chosen for more detailed aerial photo interpretation and mapping of faults. This area (Figures 3a and 3b) contains the youngest-looking faults in the Devils Garden area, as well as representative sample of the other, more degraded fault scarps.

The freshest, as well as the highest fault scarps in this area are found along the Porcupine Rim (Figure 3b). These scarps define a north-trending fault zone about 20 km long and 2-3 km wide. The highest scarp is about 50 m high (Locality 1, Figure 3b). Closed depressions are found at the base of some of the higher scarps. Well-defined graben are also present locally (Locality 2, Figure 3b). The scarps are also marked by free faces in basalt near their crests and by linear ridges and troughs in talus near their base (Locality 3, Figure 3b). Similar features were noted by Wills (1990) along the active Hat Creek and McArthur fault zones. Localities 2 and 3 were field checked by C. Wills, E. Hart, W. Bryant and J. Treiman on October 3, 1990. Locality 2 is a very sharply defined graben bounded by vertical scarps in basalt. The scarp on the west reaches a maximum height of about 2 meters while that on the east approaches 15 m. The floor of the graben is quite flat from scarp to scarp, without sloping up to either side. There is very little rubble adjacent to either scarp. Apparently any talus associated with the scarps has been buried by the alluvium in the graben.

A soil has formed on this alluvium within the graben. The B horizon of this soil has a strong angular blocky texture and thick clay films on ped faces. This relatively well developed soil in the graben implies that the alluvium is relatively old, possibly pre-Holocene. If the alluvium is pre-Holocene and covers any scarp-derived talus in the graben, the faults that bound the graben have not been active in Holocene time. Holocene movement on the faults that bound the graben would be expected to cause rockfalls from the nearly vertical scarps, creating talus on the surface of the alluvium. The lack of any talus above the alluvium suggests that there have been no major earthquakes since the alluvium was deposited, although some Holocene activity cannot be ruled out.

The scarp at Locality 3 is the highest scarp on the Porcupine Rim. This scarp is over 50 m high and has a free face at its top that is locally over 10 m high. The lower 40 m of the scarp is covered by a talus slope made up of angular boulders of 0.5 to over 3 m diameter. A trough within this coarse talus is apparent on the aerial photographs and was field checked. The talus within and above this trough has a uniformly weathered appearance with pitted surfaces on many boulders and thin (generally less than 1 mm) weathering rinds on all surfaces that were checked. It is unlike "fault stirred rubble" along active faults which has variously weathered and fresh faces on boulders (Hart, 1987; Wills, 1990). This implies that this fault has not been active in at least the past few thousand years and probably not in Holocene time. Holocene activity cannot be completely ruled out, although any that has occurred has probably been minor.

Fault scarps that are not as high, but are nearly as fresh in appearance are found along the east side of Dobe Swale (Figure 3b) and both sides of Fairchild Swamp (Figure 3b). Free faces in basalt are found along all three scarps and linear ridges and troughs are present locally along the east side of Fairchild Swamp (Locality 4, Figure 3b). The presence of these features suggest that these faults may have also been active in late Pleistocene time. Holocene activity seems unlikely because of the degraded appearance of these scarps in comparison to those of the Porcupine Rim, but cannot be ruled out.

Scarps that are slightly more degraded in appearance are found along the west side of Reservoir F (Figure 3b) and to the south. These scarps are locally sharp and fresh in appearance and have remnants of free faces but are commonly talus covered and incised by minor drainages. Based on comparison of these scarps with those along the Porcupine Rim and those along Dobe Swale and Fairchild Swamp, these faults have probably been less active in late Pleistocene time and have had little or no displacement on them in Holocene time.

Most of the scarps in the Devils Garden Plateau can be divided into three major groups. The youngest in appearance are the irregular north-trending scarps, parallel to the Porcupine Rim, Dobe Swale and Fairchild Swamp scarps. These scarps are concentrated in the south-central portions of the plateau, particularly in the area around Reservoir F (Figure 3b), and along the edge of Goose Lake (Figure 2c and 2f). The scarps are generally sharp, with little incision by streams that cross them but are talus covered and vegetated. Only the youngest of these scarps, described above, have free-faces and other features suggesting recent displacement. Based on the degree of degradation of these scarps, it seems reasonable to suppose that this group of north-trending faults formed in late Pleistocene time.

The two other major groups of scarps in the Devils Garden Plateau are the northwest-trending and northeast-trending scarps. These two groups appear to form a conjugate pattern, are about equally degraded, with rounded crests in basalt, and are incised by very minor streams. They appear to be older than the north-trending group of faults but considerably younger than the 5 to 10 m.y. old Devils Garden Basalt, as mentioned above. They are probably of Pliocene to early Pleistocene age.

CONCLUSIONS

Northwest-trending and some northeast-trending normal faults are distributed across the Devils Garden Plateau in Modoc County. Most of these faults are associated with scarps and linear ridges that are now erosionally degraded. Quaternary movement on most of these faults seems likely but Holocene displacement is not. A few north-trending faults in the south-central portion of the plateau have formed sharp, fresh scarps up to about 50 m high. The youngest of these scarps, along the Porcupine Rim, both sides of Fairchild Swamp and the east side of Dobe Swale Reservoir, have geomorphic features that suggest latest Pleistocene to Holocene displacement. Weathering of talus, the lack of "fault stirred rubble" and a well-developed soil in a graben suggest that there has been little or no Holocene activity on the freshest and youngest appearing of these faults. Other fresh appearing scarps were not field checked because of the limited time available for this study. Holocene displacement on those faults that bound Fairchild Swamp and Dobe Swale, as well as several other faults in the Reservoir F area, cannot be ruled out. These faults appear to be more degraded than those along the Porcupine Rim, however, and any Holocene displacement has probably been minor.

RECOMMENDATIONS

The faults of the Devils Garden Plateau do not appear to have clear evidence for Holocene activity and are not recommended for zoning under the Alquist-Priolo Special Studies Zones Act.

Reviewed and approved.
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REFERENCES CITED

Burnett, J.W., unpublished, overlays showing faults on the Big Sage Reservoir, Clear Lake Reservoir, Jacks Butte, South Mountain, Steele Swamp and Willow Ranch Quadrangles, unpublished mapping data in Division of Mines and Geology, Regional Geologic Mapping Project files, scale 1:62,500.

Gay, T.E., Jr., and Aune, Q.A., 1958, Alturas Sheet, Geologic Map of California: California Division of Mines, scale 1:250,000.

Gay, T.E., Jr., and Aune, Q.A., unpublished, field maps of the Hackamore, Jacks Butte, South Mountain, Steele Swamp and Willow Ranch Quadrangles, unpublished mapping data in Division of Mines and Geology, Regional Geologic Mapping Project files, scale 1:62,500.

Hart, E.W., 1987, Pisgah, Bullion and related faults, San Bernardino County, California: California Division of Mines and Geology Fault Evaluation Report FER-188, 14 p. (unpublished).

Hart, E.W., 1988, Fault Rupture Hazard Zones in California: Division of Mines and Geology Special Publication 42, 24 p.

Jennings, C.W., 1975, Fault Map of California: California Division of Mines and Geology Geologic Data Map 1, scale 1:750,000.

McKee, E.H., Duffield, W.A. and Stern, R.J., 1983, Late Miocene and early Pliocene basaltic rocks and their implications for crustal structure, northeastern California and south-central Oregon: Geological Society of America Bulletin, v. 94, p. 292-304.

U.S. Department of Agriculture, 1955, Aerial Photographs, flight BUW, numbers 4P 41-62, 74-106 and 156-161, 5P 87-97, 141-149 and 194-198, black and white, vertical, scale approximately 1:20,000.

U.S. Forest Service, 1984, Aerial Photographs, flight 615090, numbers 284-25 to -66 and -135 to -167, 384-40 to -88 and -158 to -211, 484-43 to -69, 584-98 to 154, 684-12 to -55 and -125 to -174, 784-26 to -72 and -125 to -147 and 984-58 to -61, color, vertical, scale about 1:24,000.

Wills, C.J., 1990, Hat Creek, McArthur and related faults, Shasta, Lassen, Modoc and Siskiyou Counties, California: California Division of Mines and Geology Fault Evaluation Report FER 209, 14 p. (unpublished).